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METHOD FOR ADJUSTING THE FIBROUS PROPERTIES OF PULP

The present invention relates to a method according to the preamble of claim 1 for adjusting the fibrous properties of pulp. The invention also relates to a method for manufacturing the pulp according to claim 17 and for manufacturing a fibrous product according to the preamble of claim 18.

Paper mills use different wood materials in papermaking, depending on the type of end products, such as the paper or packaging products that are made of intermediary products, such as chemical and/or mechanical or chemi-mechanical pulps. Generally, different paper grades are manufactured from both long and short fibres. Long-fibred raw material imparts strength to the paper, short-fibred material in turn imparts smoothness and printing qualities to the paper. For example, in the manufacture of the long-fibred chemical pulp portion of fine grade paper, raw material is used with an average fibre length (weighted by the length) of about 2 mm. The average fibre length of the long-fibred portion of magazine paper material should preferably be over 2.2 mm. The average fibre length of the long-fibred chemical pulp of the raw material used in the manufacture of paper (or board) that has top-quality printing and other properties should preferably be 2.3 mm. Such a raw material is called armouring (reinforcement pulp) fibre and it can be used advantageously, for example, in the manufacture of top-quality LWC (light weight coated) paper with a low basis weight. The printing properties of such paper are good, but not a great deal of material is used. The strength of the paper thus comes from the armouring fibre and the printing properties from the mechanical pulp.

In the methods currently used, the fibre length of wood is not adjusted at all or the adjustment is carried out by classifying the wood, on arrival at a plant, according to the log diameter or the felling method. When raw material with varying fibre lengths are mixed in the right proportions, the mean value of the wood's fibre length can be set at the correct level. As the fibre length of the wood from a first thinning is shorter than that of older wood, the wood from the first thinning is combined with older wood and, possibly, with sapwood. However, the problem arises that the greater the amount of young growing timber that is used as raw material, the shorter the fibre. Sawmill chips must be mixed with the raw material to increase the mean value of the fibre length in order to produce raw material with the desired fibre length for paper manufacturers. Nonetheless, it is difficult to keep the fibre length of the wood material at the desired level.

In connection with this invention, it has been observed that the fibre length of wood material obtained from the different parts of wood is different. On the basis of these observations, the surprising discovery has been made that the number of annual rings of a tree has an impact on the tree's fibre length. When the wood material is classified into categories according to the number of annual rings, and wood material is taken from a certain category, a wood material with a homogeneous fibre length is obtained.

Previously, the fibrous properties of wood have been examined for individual trees or growing timber only. The patent publication US 2001/0018308 tried to accomplish a certain fibre coarseness (less than 22 mg/100 m) and it was discovered that this goal could be reached by using treetops and wood from thinning. However, the publication neither examined the number of the trees' annual rings by log or groups of logs, nor divided the wood material into categories according to the number of annual rings. The wood was roughly divided into grown wood and young wood only and it was considered that the desired fibre coarseness would be reached in this way by taking some young wood or grown wood or both in the right proportions. This may be so for trees grown in certain conditions and for a certain tree family or species. In order to really obtain wood material with fibre dimensions of homogeneous quality, the wood material must be examined much more accurately. The publication mentioned above does not present a solution to the problem of decreasing the variation in the wood material's fibre dimensions.

The international patent publication WO 00/72652 examines standing trees or the sectional planes of cut wood by scanning them by means of electromagnetic short-wave of microwave energy and by making an image of the scanned data. In this way, various wood properties such as knots, were discovered, which cannot be observed from the outside. On the basis of the observations, the wood material was selected for various purposes, such as turning lathes, sawmills, for chemical pulp or paper. The publication also mentions observations of annual rings but nothing about observing the number of annual rings or dividing the wood material into categories according to the number of annual rings. Nor does it mention any improvements in the smoothness of the fibre dimensions of the wood material.

The Japanese patent publication JP A 11-232427, G 06T 1/00 describes a method for defining the number of annual rings, and the patent publication US 5,335,790 describes a method for classifying the wood according to the brightness and the structure or the texture of the surface.

According to the present invention, the fibrous properties of pulp, such as chemical or paper pulp can be adjusted by using, in the manufacture of chemical or chemi-mechanical pulp, a wood material, which is selected on the basis of the number of the tree's annual rings.

More specifically, the solution according to the invention is mainly characterized by what was stated in the characterising part of claim 1.

The number of the tree's annual rings correlates with its fibre dimensions, such as the fibre length and the fibre coarseness. Classifying the wood material into categories on the basis of the number of annual rings results in a wood material with homogeneous fibre dimensions. If the categories are appropriately selected, the variation in dimensions within a category is also minor. The definition of the annual rings can be mechanized and carried out at any stage between wood harvesting and pulping, if talking about making chemical pulp, or the number of annual rings can be defined at any stage between wood harvesting and grinding or refining (a (C)TMP refiner), if mechanical or chemi-mechanical pulp is made.

The wood material can be classified into categories on the basis of the number of annual rings in various ways. By now selecting the raw material from a certain category, a fibre with dimensions at the desired level can be obtained. On the other hand, combining and mixing the wood material that is divided into the different categories can result in a fibre with the desired, preselected fibre dimensions. To obtain the preselected fibre dimensions, it may be necessary to divide the annual ring categories in a different way depending on the sort of wood in question.

The invention provides considerable advantages. Accordingly, the method described herein can be used to improve the quality of wood material and to obtain a wood material with homogeneous fibre dimensions for various processes. The method according to the invention can be used to adjust the fibrous properties of chemical pulp, mechanical pulp or chemi-mechanical pulp, to adjust the smoothness of the properties and to decrease any variation in quality. The method can be used to improve the quality of fibre products. As the fibrous properties can be affected since the felling of the tree, and not until after measuring the fibrous properties, the method is also advantageous in terms of economy and production.

In the following, the invention is described more closely with the aid of a detailed specification and a few application examples.

Fig. 1 shows the correlation between the annual rings and the fibre lengths and the fibre coarseness (with standard length deviations) of the top logs of spruce, which are obtained in regeneration cutting, when the material is classified into annual ring categories;

Fig. 2 shows the correlation between the tops, which are classified according to the diameter, and the fibre length and the fibre coarseness (with standard length deviations) of spruce logs, which are obtained in regeneration cutting;

Fig. 3 shows the correlation between the butt logs, which are classified according to the number of annual rings, and the fibre length and the fibre coarseness (with standard length deviations) of spruce, which are obtained in regeneration cutting;

Fig. 4 shows the correlation between the butt logs, which are classified according to the diameter, and the fibre length and the fibre coarseness (with standard length deviations) of spruce, which are obtained in generation cutting;

Fig. 5 shows the correlation between the top logs, which are classified according to the log's age/annual rings, and the fibre length and the fibre coarseness (with standard length deviations) of spruce;

Fig. 6 shows the correlation between the top logs, which are classified according to the diameter in thinning, and the fibre length and the fibre coarseness (with standard length deviations) of spruce;

Fig. 7 shows the correlation between the butt logs, which are classified according to the annual rings in thinning, and the fibre length and the fibre coarseness (with standard length deviations) of spruce;

Fig. 8 shows the correlation between the butt logs, which are classified according to the diameter in thinning, and the fibre length and the fibre coarseness (with standard length deviations) of spruce;

Fig. 9 shows the correlation between the top logs, which are classified according to the annual rings in regeneration cutting, and the fibre length and the fibre coarseness (with standard length deviations) of pine;

Fig. 10 shows the correlation between the top logs, which are classified according to the diameter in regeneration cutting, and the fibre length and the fibre coarseness (with standard length deviations) of pine.

Pulp in the present invention refers to chemical pulp, mechanical pulp or chemi-mechanical pulp. Pulp, the fibre dimensions of which are at the preselected level, can be used in the manufacture of paper, board or packaging materials or in any other processes that utilize pulp.

According to the present method, the wood material is classified according to the number of the log's annual rings. The annual rings of a tree are formed, when the tree grows periodically, and they can be distinguished from one another. For example, in the cross-section of Finnish conifer trees, one can observe the alternating light-coloured 'springwood rings' of cells/fibres with large cavities and thinner walls and 'summerwood rings' of cells/fibres with small cavities and thick walls. In this example, the age of the log in years is obtained by counting the number of these concentric cycles. The periodic nature in turn is a consequence of the variation in the environmental conditions, such as light, heat and water supply. The alternation of seasons between a warm summer and a cold winter induces the formation of annual rings, as well as, for example, a dry summer and a rainy winter.

The classification of wood "by log" means that the number of annual rings is determined for each tree harvested from a forest, the cut parts of which are called logs. When logs are known to be close to one another in terms of the numbers of annual rings, "by groups of logs" correspondingly refers to the definition of the number of annual rings from a group of two or more logs. The classification is preferably carried out mechanically or by modelling. The division/sorting according to annual rings can be carried out at any processing stage of the wood, when making chemical pulp (after felling the tree and before pulping) or when making mechanical or chemi-mechanical pulp (after felling the tree and before grinding or before the refining process). The number of annual rings can be determined, for example, near the chopping machine, after which the logs are classified into their respective piles according to the number of annual rings. It is preferable to define the number of annual rings as early as at the chopping machine in the forest in connection with felling the wood. For example, the chopping machine can have a device at its end, which reads the annual rings in the same manner as bar code readers read bar codes. In this case, the wood material can be directly classified according to the number of annual rings, when the tree is felled, decreasing the need to classify the logs at a later stage. The classification can preferably be carried out mechanically in the plant by counting the number of annual rings or by classifying in accordance with the markings that are based on the number of annual rings or modelling and obtained by means of the felling machine.

The method according to the present invention can be applied to the manufacture of chemical or paper pulp, when using wood that has a periodic growth habit as raw material. Trees that have periods of quick and slow growth have such a growth habit, the periods resulting from fluctuations in heat, light and/or water supply, as described above.

The wood material can either be softwood or hardwood. Softwood, for example, comprises the spruce and the pine. Hardwood comprises birch, aspen, hybrid aspen, poplar, beech tree, red beech, hornbeam, oak, alder, maple, acacia and eucalyptus.

The fibre dimension property refers to the fibre length and the fibre coarseness, for example. The fibre length refers to the arithmetic mean value of the fibre length distribution, the mean value of the fibre length distribution weighted by the fibre length or the mean value weighted by the weight. Of these, the mean value weighted by the length is generally used to provide the best description of the technical potential of fibre.

The fibre coarseness refers to the weight of a fibre sequence of chemical or paper pulp, for example, the weight of a meter of the fibre sequence in milligrams. The above can be measured using equipment especially developed for this purpose, such as the FS-200 and Fibrelab instruments. The devices are based on measuring the fibre dimensions by optical measuring methods in a medium that flows in suitable filter troughs. The results obtained by means of the devices are device-specific and, therefore, not absolutely accurate. Good laboratories have developed in-house standards and calibrations for the measuring.

In connection with the present invention, we have surprisingly discovered that, when the raw material is classified into different categories according to the number of annual rings, certain desired fibre lengths and dimensions as well as extraordinary smoothness levels are achieved. The number of categories can be 2 to 60; preferably the number of categories is 2 to 6, typically 3 to 4 or 3 to 5.

According to a preferred embodiment, the classification can comprise the following categories, for example: less than 20 annual rings, 21 to 30 annual rings, 31 to 40 annual rings, over 40 annual rings. If the wood material is classified, for example, into the following categories: less than 20 annual rings, 21 to 30 annual rings, 31 to 40 annual rings, over 40 annual rings, the following correlations are obtained:

Number of annual rings	Fibre length
less than 20	2
21 to 30	2.3
31 to 40	2.4
over 40	2.5

According to another preferred embodiment, the annual rings are classified into the following categories: less than 10 annual rings, less than 20 annual rings, less than 30 annual rings, less than 40 annual rings, less than 50 annual rings, over 50 annual rings.

By classifying the raw material by log or group of logs into different categories according to the number of annual rings, the desired fibre dimension property, such as the fibre length, is obtained by selecting the wood material separately from a certain category or by combining the raw material obtained from different categories in the right proportions.

The present method can be used to manufacture mechanical, chemical or chemimechanical pulp from the selected raw material.

For example, if a fibre product is to be made of softwood, the fibre length (the mean value weighted by the length) of the product being less than 2.0 mm, typically, a wood material with less than 20 annual rings at the butt of the log should be selected. If a fibre product is to be made of softwood, its fibre length being in the range of 2.0…2.3, a wood material is selected, which has 21 to 30 annual rings at the butt of the log. Correspondingly, to obtain a fibre length in the range of 2.3…2.5, a wood material is selected, which has 31 to 40 annual rings at the butt of the log, and to obtain a fibre length in the range of 2.5…3.5, a wood material is selected, wherein the number of the log's annual rings at the butt of the log is over 40 annual rings. In the example, the butt is measured but, alternatively, measuring can be carried out at the log's top end, and the annual ring can be changed, e.g., with the aid of a model, so that it corresponds to the number of the butt's annual rings as a function of the log's length.

To obtain the preselected fibre dimensions, it may be necessary to divide the annual ring categories of different sorts of wood in a different way. The fibre lengths of birch, for example, range from about 0.7 mm to 1.2 mm and the annual ring categories must be selected so that they give the desired fibre length for this range.

The method according to the invention for manufacturing pulp that has preselected fibre dimension properties typically comprises the following processing stages:

- wood with a periodic growth habit is selected as the wood material,
- according to its annual rings, the wood material is classified by log or group of logs into categories that represent a certain fibre dimension, e.g., the fibre length and/or the coarseness,
- the raw material is selected separately from a certain category or by combining the raw materials of different categories partly or fully so that the preselected fibre dimensions are achieved, and
- mechanical, chemical or chemi-mechanical pulp is manufactured of the wood material.

Different coniferous or broad-leaved trees can be classified according to the annual ring categories of a log or a group of logs, and an improvement in quality can be achieved in the adjustment of the fibre dimensions and/or the smoothness tolerance of chemical, mechanical or chemi-mechanical pulp and utilized in improving the quality of the manufactured products.

A method according to the invention for manufacturing a fibre product that has preselected fibre dimension properties, typically comprises the following processing stages:

- categories of annual rings that represent certain fibre dimensions are defined for the wood material by logs or groups of logs and according to the number of annual rings,
- the wood material is selected from the category of annual rings, which provides the preselected fibre dimension properties,
- mechanical, chemical or chemi-mechanical pulp is manufactured of the wood material, and
- the fibre product is made of the pulp.

The following non-limiting examples illustrate the invention:

A total of 442 samples were taken of the sweep of spruce wood (from regeneration cutting and thinning) coming to the plant. The tops and butt parts of the trees were sorted separately and their percentage was determined. According to the results, the volume (and at this accuracy also) the weight fraction of the tops from the regeneration cutting was 54% and that of the butt parts 15%, and the portion of the tops from thinning was 17% and that of the butt parts was 14% of the entire sweep of spruce coming to the plant. This material was measured and classified according to the log thickness and/or the number of annual rings.

Example 1

The trees felled in connection with the regeneration felling of spruce were classified by top log, according to the number of annual rings, into the categories of <20 annual rings, 21 to 30 annual rings, 31 to 40 annual rings and >40 annual rings. The results are shown in Fig. 1.

The portion of wood in the category of <20 annual rings was 12%, the fibre length ranged between 1.98 and 2.16 (standard deviation), the average fibre length weighted by the length was 2.07 mm. The fibre coarseness in this category ranged between 0.149 and 0.160 mg/m (st.dev.).

The portion of wood in the category of 21 to 30 annual rings was 38%, the fibre length ranged between 2.20 and 2.38 (st.dev.), and the average fibre length was 2.29 mm. The fibre coarseness in this category ranged between 0.163 and 0.172 (st.dev.) mg/m.

The portion of wood in the category of 31 to 40 annual rings was 25%, the fibre length ranged between 2.36 and 2.48 mm (st.dev.), the average fibre length was 2.42 mm. The fibre coarseness in this category ranged between 0.171 and 0.178 mg/mm (st.dev.).

The portion of wood in the category of >40 annual rings was 25%, the fibre length ranged between 2.46 and 2.59 mm (st.dev.), the average fibre length was 2.52 mm. The fibre coarseness in this category ranged between 0.184 and 0.178 mg/mm (st.dev.).

Example 2

The tops of the trees felled in connection with the regeneration cutting of spruce were classified according to the diameter into the categories of <80 mm, <100 mm, <120 mm, <140 mm, <160 mm, >160 mm. When the fibre length and the fibre coarseness of the categories were measured, it was observed that the fibre lengths and the fibre coarsnesses were partly or fully overlapping, as shown in Fig. 2. For example, in the categories of <80 mm and <140 mm, the fibre lengths are fully overlapping and, thus, the classification by diameter hardly has any significance in practice.

Example 3

The trees felled in connection with the regeneration cutting of spruce were classified by butt log, according to the number of annual rings, into the categories of <30 annual rings, <40 annual rings and >40 annual rings. The results are shown in Fig. 3.

The portion of wood in the category of <30 annual rings was 10%, the fibre length ranged between 2.21 and 2.44 mm (calculated st.dev.), the average fibre length weighted by the length was 2.32 mm. The fibre coarseness in this category ranged between 0.163 and 0.175 mg/m (st.dev.).

The portion of wood in the category of <40 annual rings was 21%, the fibre length ranged between 2.40 and 2.56 mm, the average fibre length was 2.48 mm. The fibre coarseness in this category ranged between 0.173 and 0.182 mg/m (st.dev.).

The portion of wood in the category of >40 annual rings was 69%, the fibre length ranged between 2.46 and 2.68 mm, the average fibre length was 2.57 mm. The fibre coarseness in this category ranged between 0.188 and 0.176 mg/m (st.dev.).

Example 4

The wood felled in connection with the regeneration cutting of spruce was classified by log, according to the diameter, into the categories of <100 mm, <120 mm and >120 mm. When measuring and calculating the fibre length and the fibre coarseness of the categories, it was discovered that the fibre lengths and the fibre coarsenesses (st,dev.) are partly overlapping, as shown in Fig. 4.

Example 5

The top parts of the trees felled in connection with the thinning of spruce were classified according to the age or the number of annual rings into the categories of <20 annual rings, 21 to 30 annual rings, 31 to 40 annual rings and >40 annual rings. The results are shown in Fig. 5.

The portion of wood in the category of <20 annual rings was 20%, the fibre length ranged between 1.99 and 2.19 mm (st.dev.), the average fibre length weighted by the length was 2.09 mm. The fibre coarseness in this category ranged between 0.150 and 0.162 mg/m (st.dev.).

The portion of wood in the category of 21 to 30 annual rings was 47%, the fibre length ranged between 2.23 and 2.46 mm (st.dev.), the average fibre length weighted by the length was 2.35 mm. The fibre coarseness in this category ranged between 0.164 and 0.177 mg/m (st.dev.).

The portion of wood in the category of 31 to 40 annual rings was 21%, the fibre length ranged between 2.36 and 2.50 mm (st.dev.), the average fibre length weighted by the length was 2.43 mm. The fibre coarseness in this category ranged between 0.172 and 0.179 mg/m (st.dev.).

The portion of wood in the category of >40 annual rings was 21%, the fibre length ranged between 2.43 and 2.60 mm (st.dev.), the average fibre length weighted by the length was 2.51 mm. The fibre coarseness in this category ranged between 0.174 and 0.185 mg/m (st.dev.).

Example 6

The top parts of the trees felled in connection with the thinning of spruce were classified according to the diameter into the categories of <100 mm, <140 mm, <120 mm, <160 mm and >160 mm. When measuring the fibre length and the fibre coarseness of the categories, it was discovered that the fibre lengths and the fibre coarsenesses (st,dev.) are partly or fully overlapping, as shown in Fig. 6.

Example 7

The butt parts of the trees felled in connection with the thinning of spruce were classified by log and according to the number of annual rings into the categories of <20 annual rings, 21 to 30 annual rings, 31 to 40 annual rings and >40 annual rings. The results are shown in Fig. 7.

The portion of wood in the category of <20 annual rings was 4%, the fibre length ranged between 1.97 and 2.16 mm (st.dev.), the average fibre length weighted by the length was 2.06 mm. The fibre coarseness in this category ranged between 0.149 and 0.160 mg/m (st.dev.).

The portion of wood in the category of <30 annual rings was 27%, the fibre length ranged between 2.28 and 2.46 mm (st.dev.), the average fibre length weighted by the length was 2.37 mm. The fibre coarseness in this category ranged between 0.167 and 0.176 mg/m (st.dev.).

The portion of wood in the category of <40 annual rings was 33%, the fibre length ranged between 2.45 and 2.57 mm (st.dev.), the average fibre length weighted by the length was

2.51 mm. The fibre coarseness in this category ranged between 0.176 and 0.183 mg/m (st.dev.).

The portion of wood in the category of >40 annual rings was 21%, the fibre length ranged between 2.55 and 2.64 mm (st.dev.), the average fibre length weighted by the length was 2.60 mm. The fibre coarseness in this category ranged between 0.182 and 0.188 mg/m (st.dev.).

Example 8

The logs felled in connection with the thinning of spruce were classified according to the diameter into the categories of <100 mm, <120 mm and >120 mm. When measuring the fibre length and the fibre coarseness of the categories, it was discovered that the fibre lengths and the fibre coarsnesses (st.dev.) are partly or fully overlapping, as shown in Fig. 8.

Example 9

The top logs of the trees felled in connection with the regeneration cutting of pine were classified according to the number of annual rings into the categories of <20 annual rings, 21 to 30 annual rings, 31 to 40 annual rings, 41 to 50 annual rings and >50 annual rings. The results are shown in Fig. 9.

The portion of wood in the category of <20 annual rings was 2%, the fibre length ranged between 1.57 and 1.79 mm (st.dev.), the average fibre length weighted by the length was 1.68 mm. The fibre coarseness in this category ranged between 0.197 and 0.206 mg/m (st.dev.).

The portion of wood in the category of 21 to 30 annual rings was 13%, the fibre length ranged between 1.85 and 2.07 mm (st.dev.), the average fibre length weighted by the length was 1.96 mm. The fibre coarseness in this category ranged between 0.207 and 0.214 mg/m (st.dev.).

The portion of wood in the category of 31 to 40 annual rings was 14%, the fibre length ranged between 1.99 and 2.16 mm (st.dev.), the average fibre length weighted by the length was 2.08 mm. The fibre coarseness in this category ranged between 0.212 and 0.216 mg/m (st.dev.).

The portion of wood in the category of 41 to 50 annual rings was 24%, the fibre length ranged between 2.12 and 2.22 mm (st.dev.), the average fibre length weighted by the length was 2.17 mm. The fibre coarseness in this category ranged between 0.215 and 0.218 mg/m (st.dev.).

The portion of wood in the category of >50 annual rings was 47%, the fibre length ranged between 2.19 and 2.28 mm (st.dev.), the average fibre length weighted by the length was 2.24 mm. The fibre coarseness in this category ranged between 0.217 and 0.221 mg/m (st.dev.).

Example 10

The tops of the trees felled in connection with the regeneration cutting of pine were classified according to the diameter into the categories of <100 mm, <120 mm, <140 mm, <160 mm and >160 mm. When measuring the fibre length and the fibre coarseness of the categories, it was discovered that the fibre lengths and the fibre coarsenesses (st,dev.) are partly or fully overlapping, as shown in Fig. 10.